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DISTRIBUTING VALUE GAIN FROM THREE GROWTH FACTORS FOR YELLOW-POPLAR

Abstract.—A method of apportioning the maximum dollar value gain from tree growth into the amounts contributed by diameter growth, merchantable height increase, and quality improvement is described. The results of this method are presented for various sizes and qualities of yellow-poplar trees.

Many forest managers seek to enhance tree values by increasing diameter growth rates. In addition to the value increase by diameter growth, trees can increase in value by making gains in merchantable height and improving in quality as well. Thus, as a sawtimber tree grows, its gain in value for lumber can be apportioned to its d.b.h. growth, to its merchantable-height increase, and to its improvement in log grade. It is possible to determine how changes in each of these tree factors—diameter, height, and quality—add to the value increment resulting from a tree's growth, and to compare the relative contributions of each. This note describes a method for making such determinations by using yellow-poplar trees. The method described can be applied to other species by using their respective conversion values.

Procedure

Model trees were selected to represent various possible tree sizes and qualities. Measurements of these model trees ranged from 14 to 28 inches d.b.h. and from 16 to 48 feet of merchantable sawlog length. U. S. Forest Service hardwood log grades for standard factory lumber and construction and local-use classes were used.[1]

[1] Ostrander, M. D., and others. A GUIDE TO HARDWOOD LOG GRADING (revised). USDA Forest Serv., NE. Forest Exp. Sta., Upper Darby, Pa. 50 pp., illus. 1965.

Table 1.—Calculation of the percent of value increase contributed by diameter growth, height increase, grade improvement, and combination effect

Present measurements				Projected measurements			
D.b.h.	Merchantable sawlog height	Butt-log grade	Conversion value	D.b.h.	Merchantable sawlog height	Butt-log grade	Conversion value
Inches	*Feet*	*No.*	*Dollars*	*Inches*	*Feet*	*No.*	*Dollars*
14.0	24	2	3.98	16.0	24	2	6.34 (A)
—	—	—	—	16.0	40	2	7.55 (B)
—	—	—	—	16.0	24	1	7.69 (C)
—	—	—	—	16.0	40	1	10.87 (D)

To calculate the value added by each factor:

DIAMETER GROWTH: From the projected conversion value (A) subtract the present conversion value.

$6.34
−3.98

$2.36 (value added by diameter growth)

HEIGHT INCREASE. From the projected conversion value (B) subtract the present conversion value. From the remainder subtract the value added by diameter growth.

$7.55 $3.57
−3.98 −2.36

$3.57 (value added by diameter plus height) $1.21 (value added by height increase)

GRADE IMPROVEMENT. From the projected conversion value (C) subtract the present conversion value. From the remainder subtract the value added by diameter growth.

$7.69 $3.71
−3.98 −2.36

$3.71 (value added by diameter plus grade) $1.35 (value added by grade improvement)

ALL THREE FACTORS. From the projected conversion value (D) subtract the present conversion value.

$10.87
− 3.98

$ 6.89 (maximum value gain from all three factors)

VALUE INCREMENT BY FACTOR:

D.b.h.	$2.36
Height	1.21
Grade	1.35
	$4.92

COMBINATION EFFECT. From the maximum value gain subtract the summation of the value gain by each factor.

$6.89
–4.92

$1.97 (value added by combination effect)

THE PERCENT OF MAXIMUM VALUE ADDED BY EACH FACTOR:

D.b.h.: $\frac{\$2.36}{\$6.89} \times 100 = 34.2$ percent

Height: $\frac{\$1.21}{\$6.89} \times 100 = 17.6$ percent

Grade: $\frac{\$1.35}{\$6.89} \times 100 = 19.6$ percent

Combination Effect: $\frac{\$1.97}{\$6.89} \times 100 = 28.6$ percent

Total = 100 percent

Changes in the model trees were projected to represent possible natural growth patterns. Diameter growth of 1, 2, or 3 inches was allowed for all trees. A maximum merchantable-height increase of 8, 16, or 24 feet was permitted for a 1, 2, or 3 inch d.b.h. growth respectively. No merchantable-height increase was allowed for trees with the following size combinations: d.b.h. 16 inches and 16 feet or less merchantable height; d.b.h. 18 inches and 24 feet or less merchantable height; d.b.h. 20 inches and 32 feet or less merchantable height; d.b.h 22 inches and 40 feet or less merchantable height; d.b.h. 24 inches and 48 feet or less merchantable height; d.b.h. 26 inches or greater and all merchantable heights. Maximum butt-log grade improvement was restricted to one grade class. No grade improvement was allowed for butt-log grade 3 trees over 22 inches d.b.h. or for butt-log grade 2 trees over 26 inches d.b.h.

The values used for all present and projected tree sizes and qualities are the conversion values developed by Mendel and Trimble in their work on the rate of value increase for yellow-poplar.[2] They used the quality-index concept, which is based on the expected 4/4 lumber grade recovery from hardwood logs, and lumber price relatives developed from current price reports. Costs of converting the standing trees into lumber were deducted to obtain the tree conversion values. Table 1 shows the conversion value of a yellow-poplar tree with present measurements of 14 inches d.b.h., 24 feet of merchantable height, and a grade 2 butt log.

The maximum dollar value gain resulting from improving all three growth factors simultaneously was calculated for each model tree and then was separated into the value gain due to (1) diameter growth, (2) merchantable-height increase, (3) quality improvement, and (4) the combined effect. The percent of value gain contributed by each of these factors to the total value gain resulting from a combination of all the factors was then determined. Sample calculations for one model tree are shown in table 1.

A combination-effect factor—the value gain resulting from combined merchantable-height increase and grade improvement — was necessary because the gain resulting from an improvement in all three factors did not consider any improvement in grade above the original merchantable length. For example, the sample calculation in table 1 shows that the value gain due to grade improvement was based on the original merchantable

[2] Mendel, Joseph J., and George R. Trimble, Jr. THE RATE OF VALUE INCREASE FOR YELLOW-POPLAR AND BEECH. *USDA* Forest Serv. Res. Paper NE-140. 27 pp. NE. Forest Exp. Sta., Upper Darby, Pa. 1969.

Table 2.—Distribution of the maximum dollar value increase contributed by diameter, merchantable height, and quality increase for yellow-poplar trees, in percent

Present measurements		Value increase contributed by—			
D.b.h. (inches)	Merchantable height (feet)	D.b.h. growth	Merchantable-height increase[1]	Grade improvement[2]	Combination effect
PROJECTED 1-INCH D.B.H., 8-FOOT MERCHANTABLE HEIGHT, AND 1-LOG GRADE INCREASE					
Butt-log grade 1:					
16-22	16-48	55-100	0-45	—	—
24+	16-48	100	—	—	—
Butt-log grade 2:					
14	16	20	30	10	40
	24	30	20	30	20
16	16	60	—	40	—
	24	30	20	30	20
	32	30	10	45	15
18	16	50	—	50	—
	24	40	—	60	—
	32	30	10	50	10
	40	25	5	55	15
20	16	45	—	55	—
	24	40	—	60	—
	32	30	—	70	—
	40	25	10	55	10
22-26	16	35	—	65	—
	24	30	—	70	—
	32	25	—	75	—
	40	25	—	75	—
	48	20	—	80	—
28+	16-48	100	—	—	—
Butt-log grade 3:					
14	16-24	15	10	65	10
16-22	16-24	20	—	80	—
	32-48	25	5-10	65	0-5
24+	16-48	100	—	—	—
PROJECTED 2-INCH D.B.H., 16-FOOT MERCHANTABLE HEIGHT, AND 1 LOG GRADE INCREASE					
Butt-log grade 1:					
16-22	16-48	55-100	0-45	—	—
24+	16-48	100	—	—	—
Butt-log grade 2:					
14	16	30	40	10	20
	24	35	20	20	25

CONTINUED

Table 2.—Continued

Present measurements		Value increase contributed by—			
D.b.h. (inches)	Merchantable height (feet)	D.b.h. growth	Merchantable-height increase[1]	Grade improvement[2]	Combination effect
16	16	70	—	30	—
	24	35	20	20	25
	32	35	10	30	25
18	16	60	—	40	—
	24	60	—	40	—
	32	35	10	30	25
	40	40	5	55	—
20	16	60	—	40	—
	24	50	—	50	—
	32	45	—	55	—
	40	30	5	45	20
22-26	16	50	—	50	—
	24	40	—	60	—
	32	40	—	60	—
	40	35	—	65	—
28+	48	30	—	70	—
	16-48	100	—	—	—
Butt-log grade 3:					
14	16-24	20	15	45	20
16-22	16-24	30	5	60	5
	32-48	35	5	55	5
24+	16-48	100	—	—	—
PROJECTED 3-INCH D.B.H., 24-FOOT MERCHANTABLE HEIGHT, AND 1-LOG GRADE INCREASE					
Butt-log grade 1:					
16-22	16-48	60-100	0-40	—	—
24+	16-48	100	—	—	—
Butt-log grade 2:					
14	16	35	35	10	20
	24	40	20	20	20
16	16	70	—	30	—
	24	40	20	20	20
	32	40	10	30	20
18	16	70	—	30	—
	24	60	—	40	—
	32	40	10	30	20
	40	35	—	35	30
20	16	65	—	35	—
	24	60	—	40	—
	32	55	—	45	—
	40	40	5	40	15

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Table 2.—Continued

Present measurements		Value increase contributed by—			
D.b.h. (inches)	Merchantable height (feet)	D.b.h. growth	Merchantable-height increase[1]	Grade improvement[2]	Combination effect
22-26	16	50	—	50	—
	24	50	—	50	—
	32	45	—	55	—
	40	40	—	60	—
	48	35	—	65	—
28+	16-48	100	—	—	—
Butt-log grade 3:					
14	16-24	30	15	45	10
16-22	16-24	35	0-10	50	5-15
	32-48	40-50	5	40-50	0-5
24+	16-48	100	—	—	—

[1] The following log-height-increase limitations were set for computation purposes:

Original d.b.h. (inches)	*Merchantable height classes (feet) that will not increase*
16	16
18	16 and 24
20	16, 24 and 32
22	16, 24, 32 and 40
24	16, 24, 32, 40 and 48
26 and over	No increase in log height for any tree

[2] The maximum butt-log grade improvement is assumed to be one grade. No grade improvement projected for butt-log grade 2 stems over 26 inches d.b.h. No grade improvement projected for butt-log grade 3 stems over 22 inches d.b.h.

height of 24 feet. When merchantable height was increased to 40 feet, the value added by the grade factor was still based on a 24-foot merchantable length, in spite of the fact that grade improved throughout the 40 feet of merchantable length.

Results and Discussion

The distribution of the projected value gain attributable to diameter growth, merchantable-height increase, grade improvement, and the combination effect of all factors improving at once is shown in table 2 for different rates of diameter growth and merchantable-height increase.

For example, a yellow-poplar tree has a present d.b.h. of 14 inches, a merchantable height of 24 feet, and a butt-log grade 2. From the general appearance of the tree and its growing conditions it is anticipated that the tree will grow to 16 inches d.b.h., 40 feet merchantable height, and

grade 1 butt log. In this case, with the projected diameter and height growth of 2 inches and 16 feet, table 2 shows that: (1) 35 percent of the total value gain will be due to diameter growth; (2) 20 percent will be due to merchantable-height increase; (3) 20 percent will be due to improvement in grade; and (4) 25 percent will be due to the combined effect of height increase and grade improvement.

If this same tree would not increase in merchantable height because of a fork at 27 feet, the conversion-value increase would have to come from the diameter and grade improvements. Increasing these two factors will yield 55 percent of the maximum total dollar value gain. If neither merchantable height nor quality improve, then the conversion value gain would be limited to that resulting from diameter growth. This would be only 35 percent of the maximum dollar value gain obtained when all factors are improved.

Understanding what each of the three factors contributes to the total conversion value of the tree—in combination with other economic, silvicultural, and forest management knowledge—can be helpful in reaching rational decisions about timber stand improvement.

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